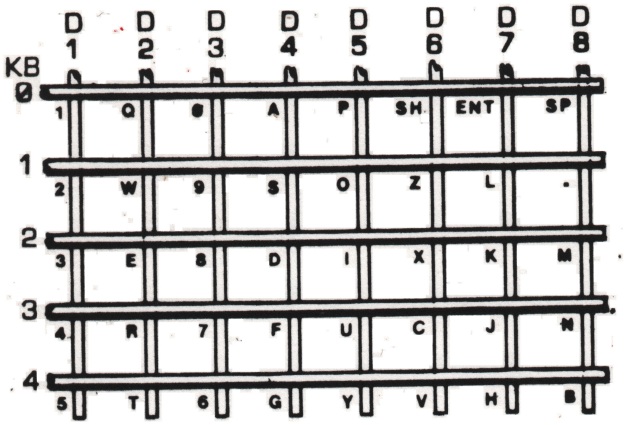
CONVERTING YOUR SINCLAIR KEYBOARD

KEYBOARD INPUT CIRCUIT

This is not written for engineers or technicians (most of whom have already converted their keyboards). Our other customers range from 9 to 90 and from male to female, and this description is to give them some idea of what happens between the computer and the keyboard.

The Sinclair keyboard talks to the computer by means of a "grid-matrix" circuit. Like many other Sinclair features, it is simple. Its main disadvantage, from our point of view, is that it requires 13 wires to connect the keyboard to the computer; but when you consider that 13 wires are used to identify 40 different keys, it could be worse!

To understand the grid-matrix circuit, imagine 8 wires, stretched vertically, and 5 wires stretched horizontally in a "grid", like this:



It is important that the 5 "KB" wires cross over the 8 "D" wires without actually touching; that's the job of the keyboard switches. (You may have noticed that this arrangement creates 40 cross-over points, and by a strange coincidence, that's how many switches are on the keyboard.) Each switch connects its two crossing wires together, whenever it is actuated.

Now, imagine that the 5 horizontal wires are each humming a different tune -- continuously. Then, when the computer circuit suddenly discovers the tune from KB3 coming in on wire D5, it doesn't take much logic to pin-point which key has been pressed.

(To make this discussion <u>really technical</u>, you have to substitute "transmitting" for "humming" and "pulse" for "tune", and there you have it.)

SELECTING A KEYBOARD

The proper keyboard for converting your Sinclair computer will be the simplest keyboard, and, therefore, usually the least expensive. It might be mounted on a printed-circuit board, or held in a metal frame with no connections to the terminals, or they might come loose in a plastic baggie. In any case there should be at least 40 key switches.

All switches on a given keyboard are identical; the SHIFT key, for example, would also work for any letter or number key. Therefore, the key caps may be pulled off and stored until needed.

Key switches for the Sinclair should be single-contact switches. They should have just <u>two</u> terminals on the bottom for electrical connections. Avoid any switches that have 3 or 4 terminals (power input, ground connections, etc.). If a PC board contains additional components, like integrated circuits and transistors, they need not affect your project. It's the <u>switch</u> that's important.

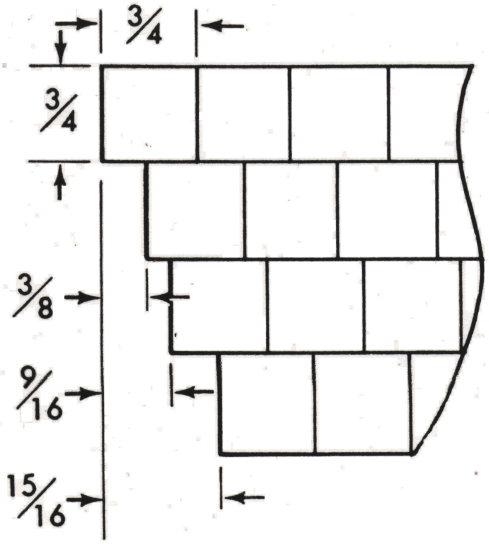
If you buy your keyboard from a mail-order house through a printed ad, you might be guided by the following terms:

Look For:	Avoid:
The word "Contact":	"Hall Effect"
(Contact switches)	"Semi-Conductor"
(Single-contact)	"Non-Mechanical"
(Plated contacts)	
(Mechanical contacts)	
"Single-pole, single throw" (SPST)	
"Matrix encoded"	

Several mailorder houses sell surplus or used keyboards for less than $20 (Local electronics surplus stores would probably charge a little more.) Often a mailorder company will not advertise a product when their supply falls below a certain quantity: so call them and describe what you want.

KEYBOARD LAYOUT

The following illustration shows the usual relationship between the four rows of key switches. It is provided for those of you who are assembling a keyboard from separate components. Notice that the shift in position between rows is not consistent.



If you are working with an assembled keyboard, you will probably use most of the existing layout as it is. Only you know what adjustments must be made to satisfy your special needs. For example, you might choose wider key caps for ENTER or SHIFT. Such changes obviously will alter the spacing between switches (normally, 3/4 inch, center-to-center). Usually, the wider keys are made in half-key increments (3/4", 1-1/8", 1-1/2").

To add a SHIFT LOCK function you must use a mechanically locking key switch. They are simple devices and most surplus keyboards have at least one.

KEYBOARD WIRING

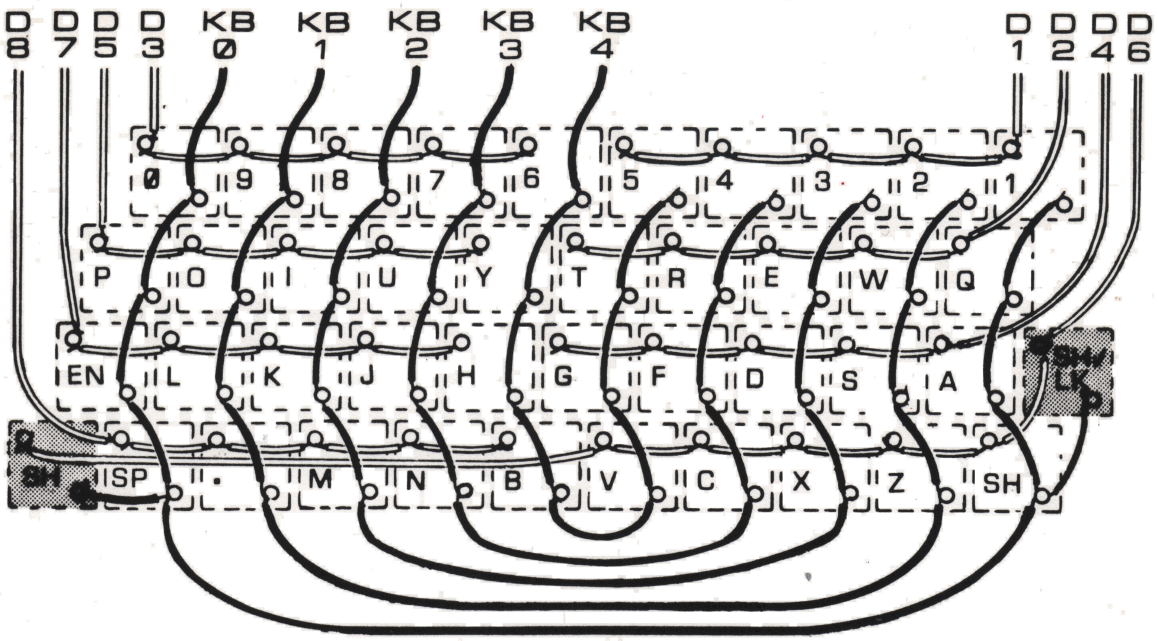
You will probably find it easiest to dismantle the original keyboard and begin the project with clean components.

Used circuit boards might have some printed traces that can be used for the new circuit, but it is often more trouble to sort them out then it is to remove them and "rewire" the board.

We believe that it is easiest to rewire the switch terminals with #26 or #28 solid, tinned, bare wire in one-foot lengths, and short pieces of plastic sleeving for insulation. This wire can be looped around one terminal, and then, after slipping on a piece of sleeving, looped around the second terminal, etc.

Other methods can be used for making PC board connections, including paste-on conductors. These closely resemble the original traces, but for this project, they are no better than wire.

You may have noticed that the wiring diagram, below, is simply a variation of the grid-matrix diagram on page 1.



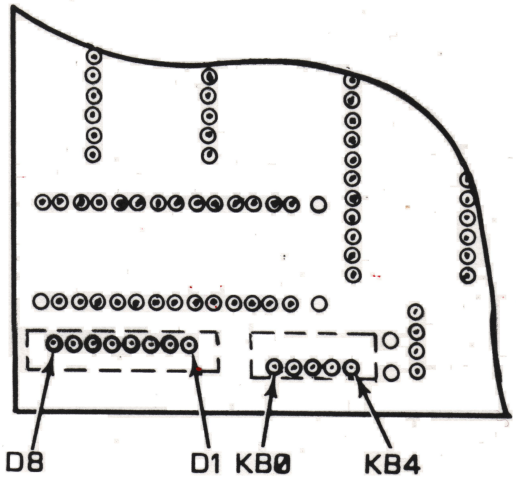
WIRING OF KEY-SWITCH TERMINALS (BOTTOM VIEW)

Two extra keys have been added (shaded gray) for a second SHIFT key and a SHIFT LOCK key. These were added only to indicate to you that two variations are possible: first, that the actual location of the keys on the board is strictly your decision; second, that any number of keys can be used for the same function. In this case, whether you were to press the right SHIFT, the left SHIFT or the SHIFT LOCK, line KBØ would be connected to line D6 which is the only thing that is important.

COMPUTER CONNECTIONS

If you want to, you can run a cable from the keyboard to the computer with soldered connections at both ends. However, most of us find that it's more convenient to be able to disconnect the keyboard from the computer from time to time. It's also pleasant, when you finish the keyboard, to have a complete "package" without a bunch of wires trailing behind. It is usually a simple matter to attach a 14-pin DIP (integrated-circuit) socket to the keyboard and solder all 13 key switch lines to that one connector. Some of these sockets can be attached to the keyboard with screws, or you can bond them in place with epoxy cement. But here we have a suggestion.

The most common cable used with DIP connectors is a flat "ribbon" cable,



KEYBOARD INPUT CONNECTIONS
(UNDERSIDE OF COMPUTER BOARD)

which has 14 (or 16) wires bonded side-by-side. They are available in various lengths with the male connector already attached to one end. They are flat enough to slip between the two halves of the ZX81 case without cutting a hole. (You may cut a thin slot along the mating edges of the case, if you want to close the case tightly.)

We have found nothing better than ribbon cable for connecting the keyboard to the computer. But, when you solder the cable to the keyboard input terminals (shown on page 3) it is impossible to match the data lines without criss-crossing all the wires in the ribbon cable. (Invariably, the wire on the left must go to the far right, etc.) We recommend that you work it out in reverse; make a neat job of connecting at the computer end, and do the necessary criss-crossing at the DIP socket on the keyboard.

SOLDERING

If you have used a soldering iron before, you will have no problem with the project. If you have never used one, it won't take long to learn. Here are a few points you might keep in mind:

The connection should be secure enough to hold without solder. Then, a thin coat of solder is applied to prevent the wire from loosening (in time), and also to prevent the formation of metal oxides, which would, eventually, interfere with its functioning. A good solder joint will be shiny; dullness indicates a crystalized or "cold-solder" joint.

SOLDERING IRON. If you buy or borrow an iron for this project, the tip should be fairly small (1/8-inch diameter) and be rated at about 45 watts. The tip should be tinned to provide a layer of liquid metal, which transfers heat to the wire connection about 10 times faster than a bare tip would. From time-to-time you must wipe the tip to remove burned-on flux and to restore the shine. A rough cloth pad will work for this purpose. Just wipe the tip across it quickly. (A pad of steel wool will also work.) Re-tin the tip whenever you think it needs it.

Rosin flux is just as necessary for soldering wires as the solder itself. When heated, the flux instantly prepares bare metal to accept the molten solder. A small amount of flux is usually held in the center (core) of the solder. (See below.)

Don't think of the soldering iron as a tool used to melt solder. Indirectly, of course, it does provide the necessary heat, but solder is seldom applied directly to the iron during the soldering process. Instead, the iron is used to heat the wires so that the solder will melt when it touches them. That way, the flux in the solder is applied directly to the wire, where it's needed, and not to the iron. Remove the iron when the solder has melted and spread.

SOLDER. Use rosin-core solder for all electrical connections. Acid-core solder should never be used on electrical connections, because the acid loves to eat copper and doesn't know when to quit.

PASTE FLUX. In addition to the rosin in the solder core, you would be wise to obtain a little container of rosin paste flux. Before you solder, apply a very thin dab of paste flux to the terminal with your fingertip. After that, your fame as a soldering craftsman is absolutely assured!

SINGLE-KEY SHIFTED FUNCTIONS

CIRCUIT DESCRIPTION

Shifted functions require that the SHIFT key be held while striking the desired symbol/function key. It is evident from this that two circuits are involved, and that they must be activated simultaneously (or, at least in the specified sequence). It is also important that they be kept electrically isolated from each other to prevent "cross-talk" through the grid system.

The following paragraphs describe two methods for obtaining shifted functions with standard single-pole keyboard switches. The first is the Diode circuit, which is extremely simple, but which works for only the first seven functions listed in Table 1. However, these seven certainly include some of those that you will want.

The second method uses a Transmission Gate, which RCA calls a Quad Bilateral Switch; "Quad" because there are four in each package, and "Bilateral" because, when closed, they will pass signals in either direction.

THE DIODE METHOD

Figure 1 shows a Shifted-Function (S/F) key using the diode circuit. The figure also lists the seven functions for which it can be used. The desired function is determined by the selected data line on the keyboard to which Diode No. 2 is connected. This same circuit, using four "typical" keys, is shown in Figure 2.

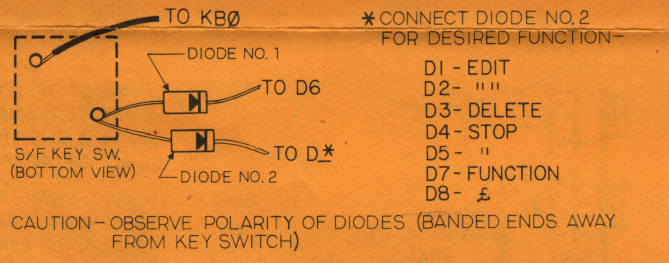


Figure 1. Single-Key Shifted Function Using Diodes

The diode method works only because the two circuits involved (the SHIFT circuit and each of the seven Function circuits) share the same KBØ output line (as shown in Table 1). The diodes are used to maintain isolation between the two "D" lines; diodes are one-way devices, and any signals that arrive at the key switch through one diode cannot go back out through the other. Because they are one-way, diodes are usually marked with a band at the "cathode" end. It is the end opposite the band which must be connected to the key switch terminal.

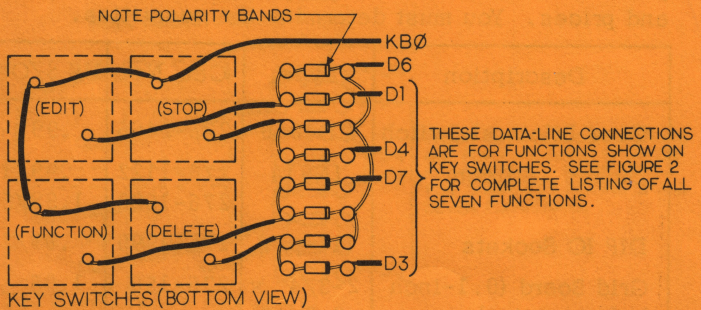


Figure 2. Typical Diode Circuit Wiring

BILATERAL SWITCH METHOD

This device is a non-mechanical, solid-state switch which closes when a control signal is applied. (See figure 3.) It is like a relay whose contacts close whenever power is applied to the magnetic coil. In this arrangement the keyboard switch no longer carries the data signals. It is used instead to supply the 5-volt control signal which holds the gates (switches) closed.

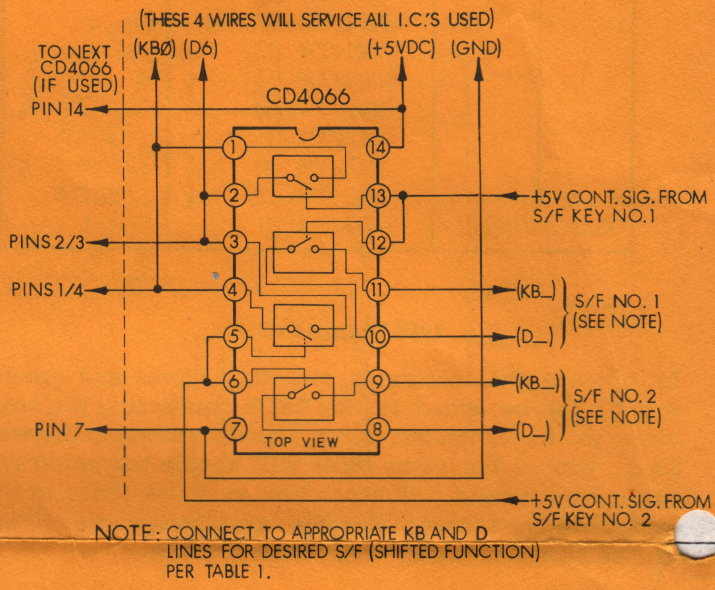


Figure 3. Two, Separate, Shifted-Function Circuits Using Quad Bilateral Switch CD4066

Each key uses two of the four bilateral switches in the IC package. Because each key uses one half of the IC, the other half may be used with another key for a second function. Then, too, several IC's can be added to the basic circuit. (Two are strung together in Figure 4.)

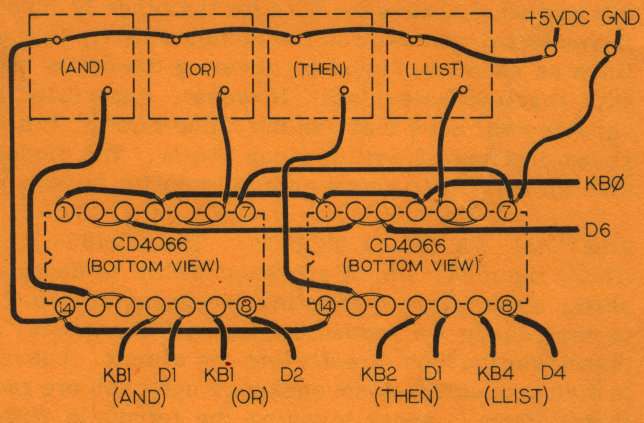


Figure 4. Typical Bilateral Switch Wiring

You will probably install the IC's on a separate mounting board, which can be attached to the keyboard with standoffs, screws and nuts, or with epoxy glue.

1st SWITCH CONNECTION	2nd SWITCH CONNECTION	FUNCTION OBTAINED		1st SWITCH CONNECTION	2nd SWITCH CONNECTION	FUNCTION OBTAINED
KBØ/D6 (SH)	KBØ/D1 (1)	EDIT		KBØ/D6 (SH)	KB2/D6 (X)	;
↕	KBØ/D2 (Q)	" "		↕	KB2/D7 (K)	+
	KBØ/D3 (Ø)	DELETE			KB2/D8 (M)	>
	KBØ/D4 (A)	STOP			KB3/D1 (4)	TO
	KBØ/D5 (P)	"			KB3/D2 (R)	<=
	KBØ/D7 (ENT)	FUNCTION			KB3/D3 (7)	↑
	KBØ/D8 (SP)	£			KB3/D4 (F)	FAST
	KB1/D1 (2)	AND			KB3/D5 (U)	$
	KB1/D2 (W)	OR			KB3/D6 (C)	?
	KB1/D3 (9)	GRAPHICS			KB3/D7 (J)	-
	KB1/D4 (S)	LPRINT			KB3/D8 (N)	<
	KB1/D5 (O)	)			KB4/D1 (5)	←
	KB1/D6 (Z)	:			KB4/D2 (T)	<>
	KB1/D7 (L)	=			KB4/D3 (6)	↓
	KB1/D8 (·)	,			KB4/D4 (G)	LLIST
	KB2/D1 (3)	THEN			KB4/D5 (Y)	>=
	KB2/D2 (E)	STEP			KB4/D6 (V)	/
	KB2/D3 (8)	→			KB4/D7 (H)	**
	KB2/D4 (D)	SLOW		KBØ/D6 (SH)	KB4/D8 (B)	*
KBØ/D6 (SH)	KB2/D5 (I)	(				

Table 1- Switch Connections for Shifted Functions

INSTALLATION

To operate the integrated circuits, power and ground wires must be added to the cable connecting the keyboard to the computer. If a 16-wire ribbon cable was used, two of the extra wires will handle the power requirements nicely. If two wires must be added to the cable, use the thinnest, flexible, insulated wires. They will be required to carry very little current.

The +5VDC and GND terminals on the computer board are indicated in Figure 5. At the keyboard end it is best to connect the power and ground wires to two insulated terminals. (If the keys are mounted on a PC board, the terminals can be a couple of brass screws in an unused area of the PC board.)

DIODE CIRCUITS. For any of the first seven functions listed in Table 1, you will certainly want to use the diode method, and save the IC's for the other 32 functions. If you wish, you can run the diodes directly to the data lines as shown in Figure 1, covering the entire "string" with insulated sleeving. However, especially if you have several keys that use the diode circuit, the layout shown in Figure 2 will be much neater. The diodes will take up very little space on any mounting board.

BILATERAL SWITCH CIRCUITS. The CD4066 IC's are CMOS devices, which are susceptible to damage from static electricity, before and during installation. This is the reason we recommend using DIP sockets, rather than soldering them directly into the circuit. Leave them in their conductive-foam packages until you are ready to install them. Avoid touching the terminals with your fingers - handle them by the ends of the plastic case. If the terminals must be bent inward to fit the socket, press the whole row against a flat metal surface.

The "typical" circuit shown in Figure 4 has several "unreal" qualities. First, the keys will not be located so conveniently, but remember, you can run the wires anywhere. Also, we show eight data lines at the bottom of the figure. Actually, you would want to conserve the number of wires to the keyboard, so the two KB1's would be connected together at the IC terminals, and a single line would serve both circuits. (The same applies to the two D1's, etc.)

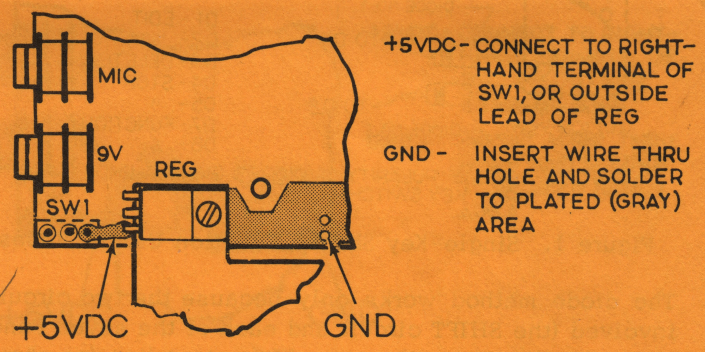


Figure 5. Power Connections at Computer Board

PARTS REQUIREMENTS

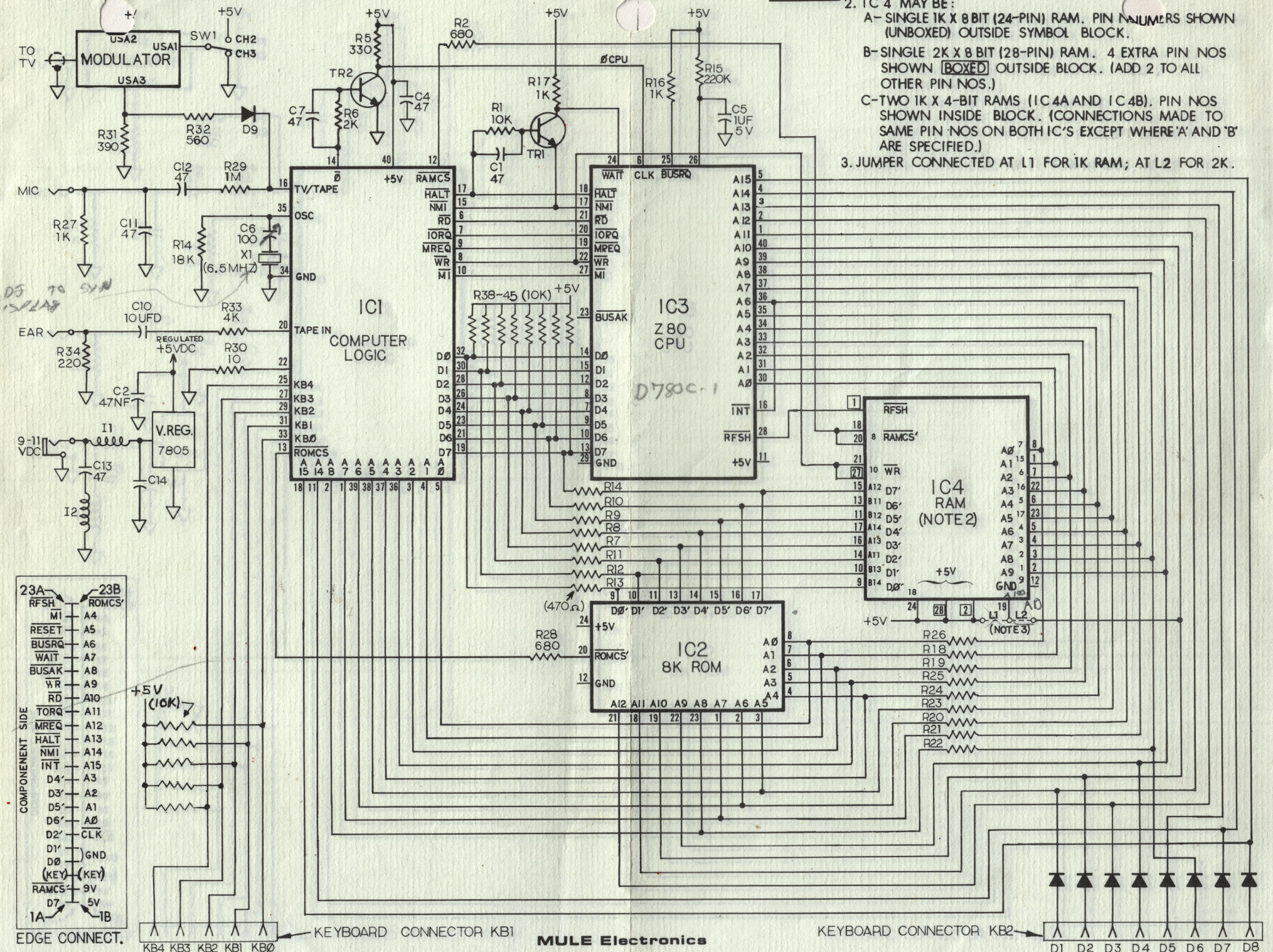
For reference, the following listing of the electronic components includes current Radio Shack catalog numbers and prices. You must determine the quantities.

Description	Type	Cat. No.	US $/Qty
Quad Bilateral Switch	CD4066	276-2466	.99
Diodes, Silicon	1N914	276-1122 276-1620	.99/10 1.98/50
DIP IC Sockets	(14-pin)	276-1999	.89/2
Grid Board (0.1-inch hole-spacing) or equivalent	2-3/4" x 3-3/4"	276-158	1.95
	5-1/2" x 3-3/4"	276-161	2.95

TS1000/ZX81 Schematic Diagram

NOTES

1. RESISTOR VALUES IN OHMS; CAPACITORS IN MF.
2. IC 4 MAY BE:
   - A- SINGLE 1K X 8 BIT (24-PIN) RAM. PIN NUMBERS SHOWN (UNBOXED) OUTSIDE SYMBOL BLOCK.
   - B- SINGLE 2K X 8 BIT (28-PIN) RAM. 4 EXTRA PIN NOS SHOWN [BOXED] OUTSIDE BLOCK. (ADD 2 TO ALL OTHER PIN NOS.)
   - C- TWO 1K X 4-BIT RAMS (IC 4A AND IC 4B). PIN NOS SHOWN INSIDE BLOCK. (CONNECTIONS MADE TO SAME PIN NOS ON BOTH IC'S EXCEPT WHERE 'A' AND 'B' ARE SPECIFIED.)
3. JUMPER CONNECTED AT L1 FOR 1K RAM; AT L2 FOR 2K.



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